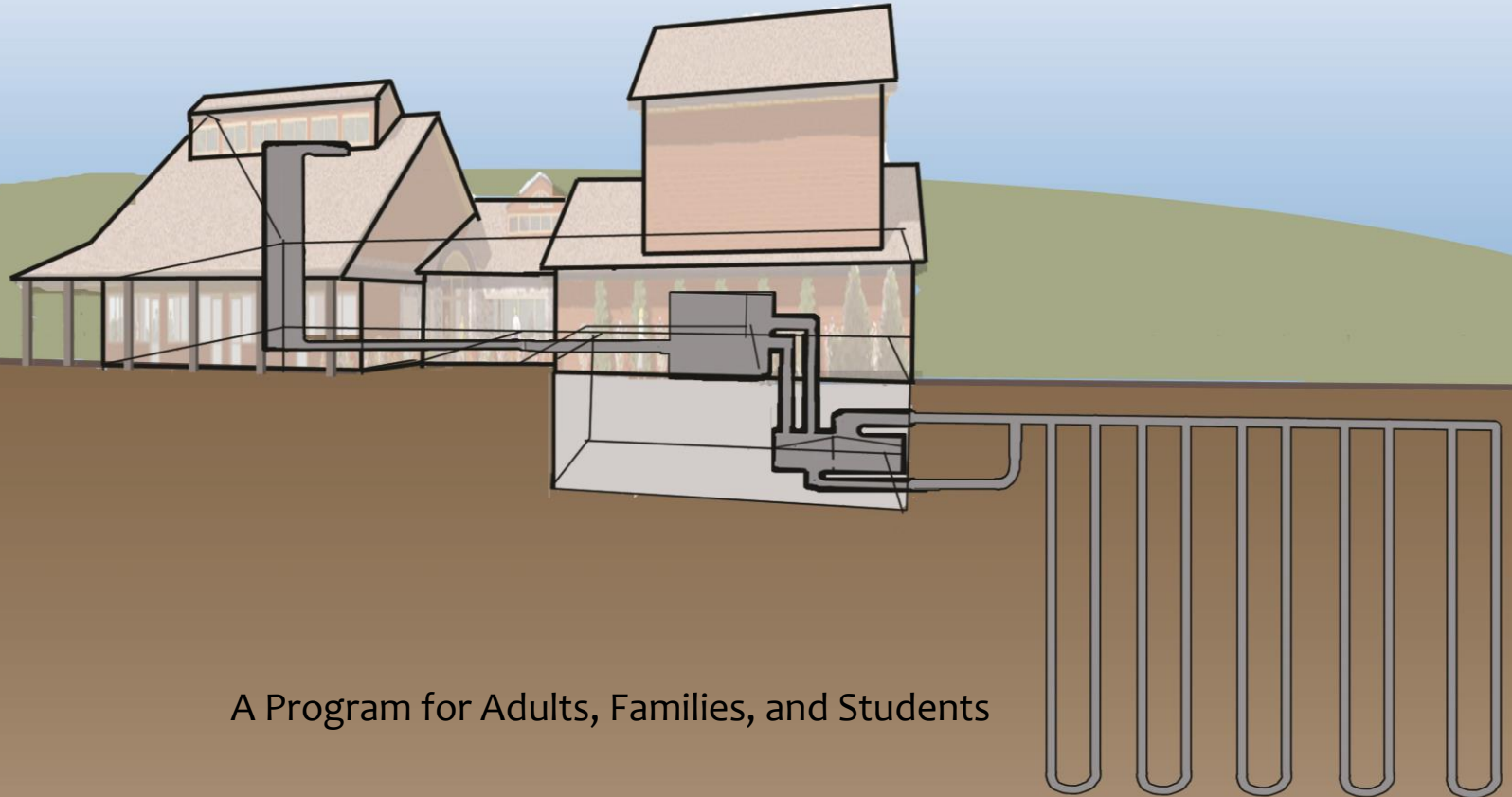


# The Closed Loop Ground Source Geothermal Heating and Cooling System at Retzer Nature Center



A Program for Adults, Families, and Students

## History & Background



## GEOHERMAL SYSTEMS—A GREAT IDEA!

In SE Wisconsin, the sub-surface temperature of the ground is about 55 degrees (Fahrenheit), no matter what season of the year. The ground temperature can be used to provide heating in winter, and cooling in summer. A system that does this is called a ground source or geothermal\* heating and cooling system.

Geothermal systems are a great way to use the natural energy of the earth, without wasting energy, burning fossil fuels, adding CO<sub>2</sub> to the atmosphere, or causing any pollution at all!.

During winter when our surface temperatures are cold (below freezing), the geothermal system picks up heat stored by the earth in its sub-surface and uses it to heat our homes and buildings to a comfortable temperature. The geothermal system is tapping into the earth as a source of heat that we can use. This is completely different from a furnace, which burns fuel to get heat. The geothermal system doesn't burn anything!—it moves heat from a place where we don't want it, to a place where it's needed!

During summer when our surface temperature is hot, the geothermal system picks up unwanted heat from our homes and buildings, and sends it down into the earth, where the earth absorbs the heat. The geothermal system is using the earth as a place to drop off un-wanted heat. The earth acts as sink for the heat, letting us cool our homes and buildings to a comfortable temperature. In effect, the geothermal system is tapping into the earth as a source of 'coolness' that we can use.

\*Note that the word 'geothermal' also refers to systems that use heat from volcanically heated water and steam; this is not the meaning that we are using here.



## Carrying the Heat!

In order to use the earth as a source for heat, or as a sink for heat, we need a heat transfer fluid, to carry heat from where we don't want it to where we do want it; A good heat transfer fluid needs to flow easily through pipes, from one place to another. It should have a good ability to hold and carry heat. This ability is called a high specific heat.

Water has these abilities—but water freezes at 32 degrees, and we need our heat transfer fluid to stay liquid down to a colder temperature. Dissolving some kind of salt or antifreeze in the water would lower its freezing temperature (this is called freezing point depression—it's what salt does to ice on a sidewalk). But since salt would tend to corrode the metal parts of the equipment, the best choice would be some kind of antifreeze.

The heat transfer fluid used in Retzer's geothermal system is a 25% solution of propylene glycol\*\* (a type of antifreeze) in water. This heat transfer fluid, called glycol, flows through pipes that are well insulated so it doesn't lose the heat that it's carrying until we want it to. The glycol flows from one place to another through a closed loop of pipes. In some geothermal systems, these pipes are buried horizontally in the ground, at a shallower depth; however, our pipes at Retzer go down into deep ground wells. Here at Retzer we have 30 wells in all, and each well is 200 feet deep! The glycol circulates through these pipes, down into the ground wells, and then they come back up into our buildings. Two hydraulic pumps, which are 3 horsepower each keep the glycol moving through the pipes.

\*\*Note that propylene glycol is not toxic—it's actually used in the food industry!—and not harmful to the environment if it spills. It acts as a penetration enhancer, which helps maintain the temperature of food. It helps to keep food products from melting in heat, and from freezing when it's cold.



## Heat Pump—Loading and Unloading the Heat!

A heat pump uses a process called refrigeration to load heat into the glycol or to unload heat out of the glycol. In the winter, the glycol circulates down through the wells and picks up heat from the earth. The glycol comes up out of the geothermal wells at the temperature of the earth, which is approximately 55 degrees. This is warmer than the temperature at the surface, so we want to use the heat from the glycol to warm our buildings. The heat pump gets heat out of the glycol by using refrigeration coils that pull out the heat and concentrate it. The heat is then transferred into the indoor air, and fans circulate the heated air throughout the building.

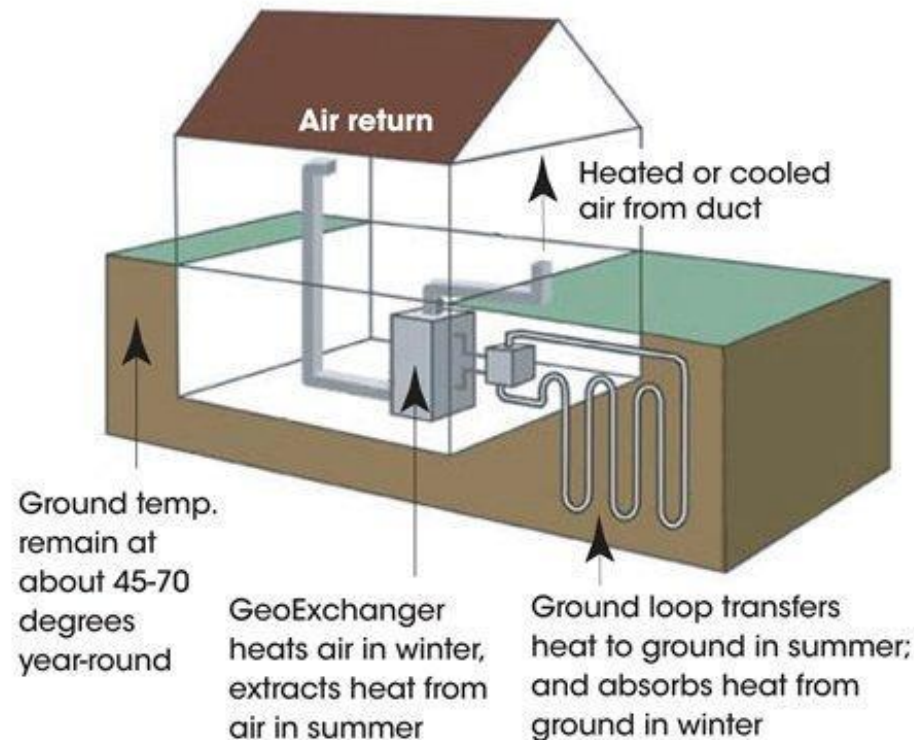
In summer, glycol circulates in the opposite direction. The heat pump's refrigeration coils now pick up heat from the indoor air in the building, concentrate the heat, and transfer it to the glycol. The glycol then circulates down into the wells deep in the ground, where it drops off the heat it is carrying as the ground temperature cools it. When the glycol comes back up into the building, its temperature is about 55 degrees, and it's ready to pick up more heat from the building. As this happens continuously, the temperature of the building gets steadily cooler.

Our geothermal system at Retzer currently serves the Maintenance Center (which has 3 heat pumps), and the older portion of the Visitor Center (which has 4 heat pumps). Extra piping was also built in the Visitor Center, so the system can be further expanded in the future. When the high efficiency furnaces in the Learning Center wing and the Planetarium are eventually replaced, heat pumps will take their place as part of the completed geothermal system.



## The Refrigeration Process—Just Plain Cool!

For most people, it is enough to understand that a heat pump picks up heat & concentrates it, so it can be moved from one place to another; they accept this and don't worry about exactly how it happens.



But, if you want to know how the heat is picked up, concentrated, and moved, read on about the details of the process used which known as the refrigeration process!



## How the Refrigeration Process Works

The heat pump contains refrigeration coils, just like an air conditioner and a refrigerator have. This is where the refrigeration process takes place. In the refrigeration process the heat is moved and concentrated by coils that are filled with a specific chemical coolant called a refrigerant. In the past a chemical called R22 or Freon—one of a group of chemicals called chloro-fluorocarbons (CFCs)—was commonly used as a refrigerant in air conditioners and refrigerators. However, the chlorine that Freon contained reacts with atmospheric ozone, resulting in the destruction of the stratosphere's ozone layer that protects us from UV radiation. Modern refrigerants that do not cause damage to the ozone layer now replace Freon.

The refrigerant moves and concentrates heat by means of a change of phase. Change of phase a term from chemistry that refers to the evaporation of a liquid to a gas, or the condensation of the gas back to a liquid. Familiar changes of phase are when water boils and evaporates on the stove, or when water vapor condenses to fog and dew in cool weather. These familiar changes of phase happen because of change in temperature – the heat from the stove causes the water to boil, and the cooling of the air causes condensation. However, the refrigerant coils in the heat pumps used in the geothermal process cause a change of phase not by heating or cooling, but by using a change in pressure. Inside the coils, the refrigerant is either compressed or expands, letting a change of phase move and concentrating a very large amount of heat. Whether the refrigerant expands or is compressed depends on the season.



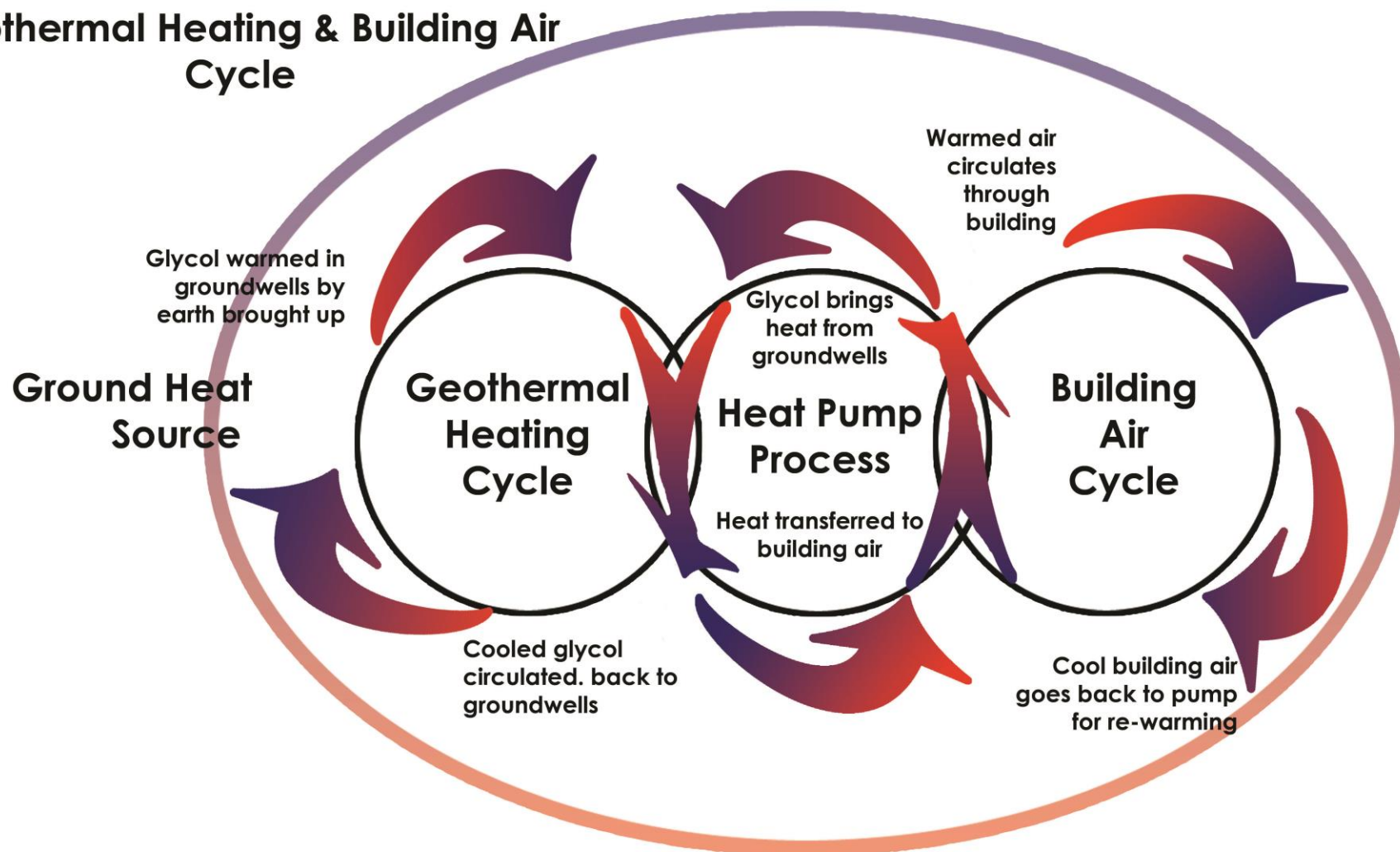
## Winter

In winter, when warmed glycol comes up out of the ground wells, it circulates through the heat pump next to the refrigerant coils. The pressure within the coils is reduced, which lets the refrigerant expand and partially evaporate into a gas within the coils. Since a gas is a higher-energy state of matter than a liquid, evaporation of the refrigerant into a gas state pulls a large amount of heat energy out of the glycol and concentrates it into the refrigerant. The refrigerant in the coils is then compressed and its pressure is increased, forcing it to condense back into a liquid state. This compression releases the heat energy into the room air, which has been brought next to the coils. The warmed air is now circulated out into the building.



# Winter

## Geothermal Heating & Building Air Cycle



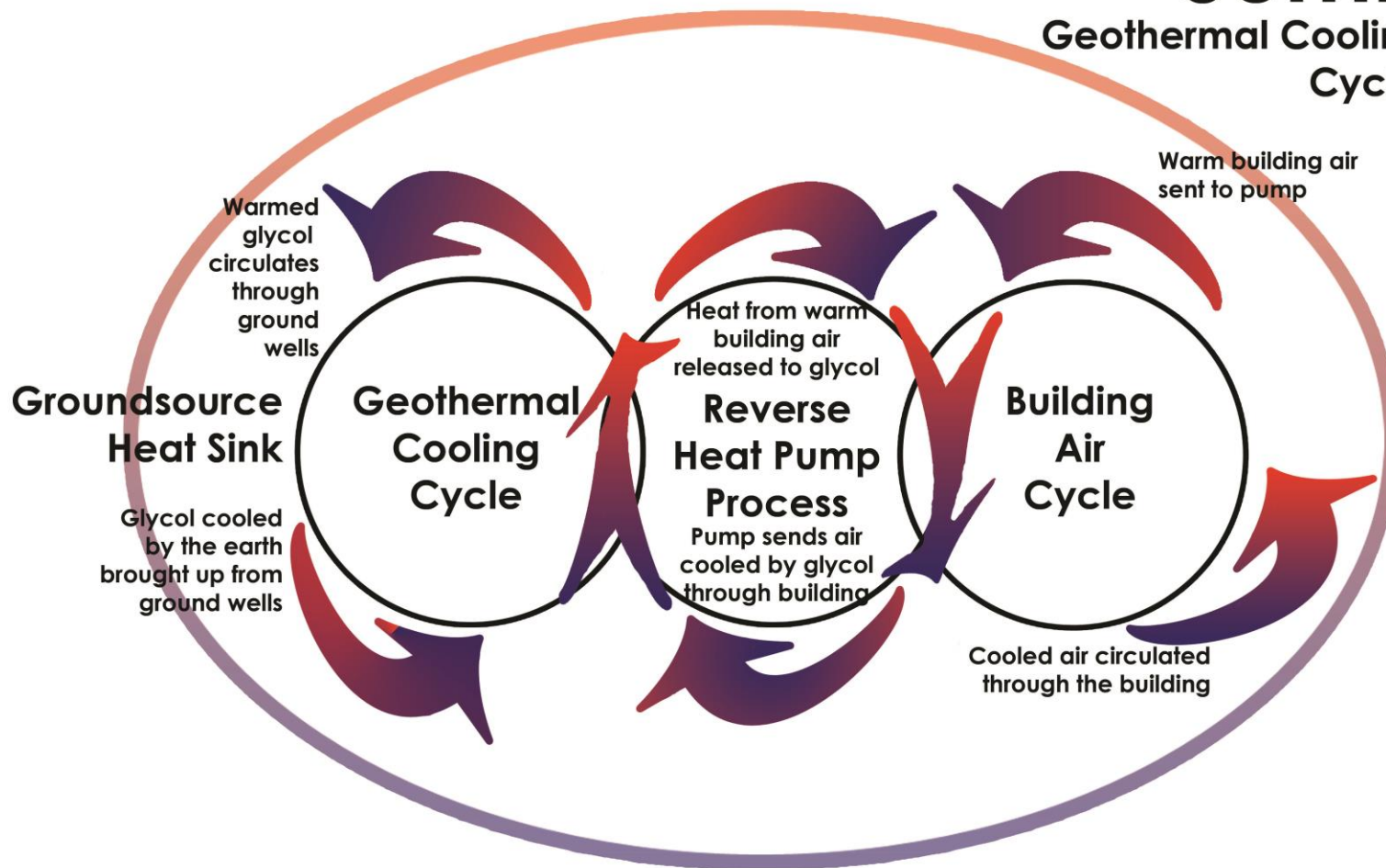
## Summer

In summer, the heat pump process is reversed, and it operates backwards from before (it now operates very much like a regular air conditioner!). Warm air from the building is circulated next to refrigerant coils. The pressure within the coils is reduced, letting the refrigerant expand and partially evaporate into a gas within the coils. Since a gas is a higher-energy state of matter than a liquid, evaporation of the refrigerant into a gas state pulls a large amount of heat energy out of the room air, and concentrates it into the refrigerant. The refrigerant in the coils is then compressed and its pressure is increased, forcing it to condense back into a liquid state. This change of phase releases the heat energy the refrigerant was carrying into the glycol circulating next to the coils. The warmed glycol circulates out of the building, carrying the heat energy out of the building and down into the ground wells, where the heat is absorbed into the earth.



# Summer

## Geothermal Cooling & Building Air Cycle



## The Benefits of Geothermal Energy

Maybe the refrigeration process was a bit much to grasp (we warned you!)—but the easiest way to think of it is that it's the active processes inside a heat pump, that use the changes of phase known as evaporation, caused by the low pressure expansion, and condensation, caused by the high pressure compression. The evaporation, expansion, condensation, and compression help to load, carry, and unload heat. The refrigeration process lets us move heat from place to place.

One of great things about a geothermal system is that it does not burn anything. Geothermal systems use the natural energy of the earth. They do not use any fossil fuel, they have no exhaust, and they do not produce CO<sub>2</sub>, or any other greenhouse gas, or air pollution of any kind!

Another great thing about a geothermal system is the payoff! A geothermal system is a smart investment, because the entire cost of equipment and installation of a geothermal system will be paid off by the money you save on your monthly heating and electric bill. It usually takes about 10 years to recoup the costs associated with a geothermal system. After that, the money you save each month on your energy bills is real savings!



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